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PLANS FOR THE COMING YEAR

The Board of Editors is pleased to announce that effective January 1962, RESEARCH MANAGEMENT will shed its quarterly status and assume the mantle of a Bimonthly Journal. The Board has long considered the advisability of this transition. Its advantages are obvious: better service to our readers; more timely presentation of subjects having current interest; greater opportunity for the publication of desirable papers; and more continuity. We have now reached the point where we believe we can accomplish all these objectives and so we make the change in the confidence that it meets with your approval, and that we will continue to merit your support.

ABOUT THIS ISSUE

How does the health of research personnel compare with that of other segments of the population? To the best of our knowledge, there has been no published report containing an analysis of data in answer to the question. We are happy, therefore, to present an article entitled "The Health of Research Personnel." It was written by Sidney Pell, biostatistician, and Allen J. Fleming, medical director, both of E. I. du Pont de Nemours, a company which has achieved a well-earned reputation for the quality of its medical service. We are confident that the article will be received by our readers with greater-than-ordinary interest.

"Expediting the Transition from Research to Production" was one of the lively topics of discussion in the IRI study group conferences of 1961. Quite a few of the participants presented case histories to illustrate measures taken by their organizations to hasten the commercialization of certain projects. We now record an outstanding case history of Marlex, the polymer first introduced by the Phillips Petroleum Company. C. Keith Buell, Manager of Process Development, gives a vivid account of this project, largest in the history of the organization. How the transition from research to production was accomplished within a span of three years will be of interest to all who have a stake in organized research. His article is entitled "The Development of Marlex."

With this issue we complete our reports on the Proceedings of IRI Study Group Conferences for 1960. "Improving the Technical Competence of Research Workers" was the subject of two study groups led by William E. Hanford, Vice President for Research, Olin Mathieson Chemical Corporation, and Carl O. Tongberg, Executive Vice President, Esso Research and Engineering Company. A total of 35 research executives attended the

sessions and all of them contributed to the lively discussions which are summarized and presented as our third article.

An optimum "climate for discovery" is achieved when the goals of an organization, and the scientist's devotion to his profession are blended into a harmony of interests. A sociologist examines the intricate elements involved, and recommends a course of action which will produce the desired environment. "The Professional Committments of Scientists in Industry" was written by Prof. Simon Marcson, Industrial Relations Section, Princeton University.

A research center is an example of a society largely inhabited by persons of advanced education and training. However varied the organizational structure may be, there is a common feature: At the apex is the research director. His job is not to do research; it is to achieve the objectives of the research center. How well he accomplishes the function depends in large measure on his success in relating the individual aspirations of his people to the organization goals. We present a competent analysis of the deep psychological factors involved. "A Motivational Approach to Research Management" was written by James N. Farr, Consultant Psychologist of the firm of James N. Farr Associates.

Doing good work is one thing: making it known to others is quite another. Between performance and recognition exists an age-old gap which men, from time immemorial, have tried to bridge by various and sundry means. The modern device goes by the name of Public Relations. An expert in that field tells what it can do for a research organization. "Why Not Let Public Relations Work For You," was written by G. Edward Pendray, Senior Partner, Pendray & Company.

The scientist in industry knows that his company will provide the human and material resources needed to exploit his discoveries. How about the "lone wolf" who works on a research project and decides that it could form the basis of a business with himself at the head? The chances are excellent that he will need the services of a financier. The latter appreciates the value of

technical competence, but other aspects, often overlooked, are also considered indispensable. The article entitled "Financing of Venture Projects" is a down-to-earth discussion of the problems involved. The author, Don C. Wheaton, Jr., is Vice President, Chemical Department, Empire Trust Company.

The American Society of Mechanical Engineers recently published a survey of current opinion on the means to shorten the time lag between discovery and engineering application. Entitled "Ideas, Inertia and Achievement," the book is reviewed by Norman A. Copeland who is Assistant Director of Research and Development in the Film Department of E. I. du Pont de Nemours & Company.

RESEARCH MANAGEMENT VOLUME IV, NUMBER 4 (1961)

THE HEALTH OF RESEARCH PERSONNEL

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Biostatistician

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An opportunity to evaluate the health of industrial research personnel in terms of their morbidity and mortality experience has grown out of a series of studies of employee health that have been in progress for several years in the Medical Division of the du Pont Company.

One of these studies is an intensive analysis of absenteeism due to prolonged nonoccupational sickness. Data are obtained from claims filed under the Company's group accident and health insurance plan, the purpose of which is to provide funds to assist in meeting medical expenses for illnesses that result in disability of more than one week. Participation in the plan requires at least six months of service, and about 96% of those eligible are

* Sidney Pell has a doctorate in biostatistics from the School of Public Health of the University of Pittsburgh. Since 1955, he has been associated with the Medical Division of du Pont where he conducts studies on the health of the employee population. His papers have appeared in the *Journal of the American Medical Association* and similar periodicals.

† Allan Fleming received his Doctor of Medicine degree from McGill University. He has been associated with the du Pont organization for about 25 years; as Director of its Medical Division, since 1954. He is a past president of the American Academy of Occupational Medicine, and a fellow of several other medical societies. He is co-author of the reference book, Modern Occupational Medicine.

members. One of the features of the plan essential to our study is that the attending physician describe and certify the cause of disability.

Another project is devoted to an analysis of deaths among Company employees. Information is obtained from the insurance claims filed by the beneficiaries under the Company's group life insurance plan, in which all persons with more than one year of service participate, and from the records of periodic physical examinations given to all employees by Company physicians. These sources provide data such as plant location, medical history, sex, age, occupation, and cause of death.

Our evaluation of the health of employees engaged in research is based on data obtained from these two studies. Illness rates and death rates in a group of research workers were compared with those of other male salaried employees in the Company, and, where possible, with rates in the general population. Our study of morbidity covers the three-year period, 1956 through 1958; and the mortality study, the six-year period, 1955 through 1960.

The Research Group

Research employees are located in various installations throughout the country, but the largest single concentration is at the Experimental Station at Wilmington, Delaware. We have limited our study to male salaried employees at this location in order to confine our subjects to one geographical area and to one in which we have readily available information. Most of these employees are professional men who are directly involved in research projects, while a minority consists of laboratory technicians and men who perform administrative functions relating to research activities. The study group does not include hourly paid laboratory helpers.

During the past six years the average population of the study group has been 1,748. A breakdown by age is shown in Table I.

TABLE I
Population of Research Group by Age, 1955–60

Age	Number
20–24	28
25–29	235
30–34	408
35–39	372
40–44	308
45–49	184
50–54	115
55–59	65
60–64	33
Total	1,748

The men in the group are predominantly young, the median age being 37.7 years.

Morbidity

In a discussion of morbidity it is important to distinguish between the two basic measures of illness in a population: incidence rates and prevalence rates. An incidence rate indicates the proportion of individuals who become ill during a specified period of time. It does not include illnesses whose onset occurred prior to the time period and continue to be present during the time period. The prevalence rate, on the other hand, specifies the proportion of individuals in the group who are ill at a certain point in time, such as a single day. The numerator of this rate includes persons who became ill on that day or prior to that day.

Prevalence of Prolonged Sickness Absenteeism

Morbidity data applicable to the population of the United States have always been scarce. Even more scarce have been illness statistics in the general population comparable to the figures we gather on absenteeism due to prolonged illnesses, those which

cause disability of more than one week. In recent years, however, the United States Department of Labor has been conducting periodic sample surveys of the nation's labor force which include a questionnaire to determine whether, on a particular day, a sick but regularly employed individual has not been at work for more than a week because of his illness. The findings of these surveys are published monthly.[1] The prevalence rate is the number of such ill individuals divided by the total employed civilian labor force. A rate of 10 per 1,000, for example, indicates that, on an average day, of every 1,000 regularly employed persons, 10 are not at work because of an illness resulting in disability of more than one week.

These rates cannot be obtained directly from the data we collect routinely, but they can be estimated from our incidence figures. During the three-year period of our study, from 1956

TABLE II
Prevalence of Illness[a] Among Three Groups
(1956–1958 inclusive)

	Prevalence rate per 1,000	Ratio to U.S.
Research group	5.5	0.43
Other male salaried personnel	7.0	0.54
U.S. civilian labor force	12.9[b]	1.00

[a] Illness resulting in disability of more than one week.
[b] Estimated rate for male workers.

through 1958, the average prevalence of illness resulting in disability of more than one week was 5.5 per 1,000 in the research group, 7.0 per 1,000 among other male salaried employees in the Company, and 14.2 per 1,000 in the U.S. civilian labor force. (Table II.) Clearly, the rate in each Company group was considerably below that of the United States.

These comparisons with the national population do not take into account certain extraneous variables we are unable to control

with the data available to us. The Company employees are, on the whole, somewhat younger than the nation's total labor force, and the labor force statistics include women, whose absence rates are usually higher than those of male workers. Both of these factors tend to increase the difference between the rates in the Company and in the general population, but probably to only a small degree.

The prevalence rate among male workers only in the U.S. civilian labor force can be estimated by applying our own data to the nationwide rate. The rate among our female salaried employees was 10.5 per 1,000. When the absences of the female employees are added to those of the men, the prevalence rate per 1,000 is increased from 7.0 to 7.7. Therefore, the male rate alone is 90.9% of the combined rate (7.0/7.7). Thus, if the difference in the rate of sickness absenteeism between men and women were relatively the same in the U.S. population as it is in the du Pont Company, the prevalence rate among male workers in the U.S. civilian labor force would be 90.9% of 14.2, or 12.9 per 1,000. Using this corrected figure as a basis, we still find that the experience of the research group is particularly favorable, having a rate only 43% of that in the general population.

Incidence of Absenteeism Due to Prolonged Sickness

During the three-year study period, there were 381 absences in the research group, and its average population during this time period was 1,573. Thus, the average annual incidence rate was 80.8 per 1,000. The rate among other male salaried employees, adjusted to the age distribution of the research group, was 84.9 per 1,000. Between the two groups there is a greater relative difference in prevalence rates than in incidence rates; that is, the ratio of prevalence rates is 0.79 (5.5/7.0), while the ratio of incidence rates is 0.95 (80.8/84.9). The reason for this is that the average duration of disability was lower in the research group: 24.7 days compared to 27.5 days.

A comparison of incidence rates by cause of disability between the research group and other male salaried employees is shown in Table III. This comparison is more revealing of the health status of the research group than would be one with the general population because the two company groups are comparable with respect to age, sex, and socio-economic background.

TABLE III

Incidence of Illness[a] in Research Personnel and Other Male Salaried Personnel (by cause of disability, 1956–58)

Cause of disability	Number of absences in research group	Average annual age-adjusted incidence rates per 1,000		Ratio: research group/ other male salaried
		Research group	Other male salaried	
All causes	381	80.8	84.9	0.95
Respiratory infections[b]	106	22.5	16.5	1.36
Digestive diseases	68	14.4	18.0	0.80
Hernia	18	3.8	4.9	0.78
Appendicitis	11	2.3	2.8	0.83
Gall bladder disease	10	2.1	1.8	1.15
Peptic ulcer[b]	8	1.7	3.7	0.46
Other digestive diseases	21	4.5	4.7	0.94
Cardiovascular diseases	48	10.2	10.7	0.95
Heart disease	22	4.7	4.1	1.14
Hemorrhoids[b]	11	2.3	4.0	0.58
Other cardiovascular diseases	15	3.2	2.6	1.21
Nonrespiratory infections	27	5.7	6.5	0.88
Musculo-skeletal disorders	25	5.3	6.6	0.81
Genito-urinary disorders	19	4.0	5.2	0.78
Accidents (off-the-job)[b]	14	3.0	4.6	0.65
Neurological diseases	9	1.9	2.8	0.67
Mental disorders	4	0.8	1.3	0.62
Cancer	3	0.6	1.4	0.45
All other causes	58	12.3	11.3	1.08

[a] Illness resulting in disability of more than one week.

[b] Probability that the difference in rates between the two groups would occur by chance alone is less than 0.05.

As seen in Table III, the absence rate for respiratory infections was 36% higher in the research group. This is the only disease category in which there was a significant excess of absenteeism among the research workers. A possible explanation for this may be that the members of the research group were more severely affected by the "Asian flu" epidemic that occurred during the fall of 1957 and early in 1958.

Among the other causes of disability shown in Table III, there are three in which the rate in the research group is significantly lower: peptic ulcer, hemorrhoids, and accidents. For all other causes of disability there were no significant differences between the two groups.

Mortality

Because of the rare occurrence of deaths in the research group, there are very little data available to describe mortality experience. During the six-year period of study, extending from 1955 through 1960, 25 deaths were recorded. Nevertheless, the small amount of information we do have is interesting and revealing.

Death rates in the research group were compared with those among white males in the United States during 1958.[2] Differences in rates for all causes and for the ten leading causes of death in the United States are presented in Table IV. The "expected number" shown in Table IV is the theoretical number of deaths that would have occurred in the research group if the national death rates in each ten-year age category prevailed in the corresponding age category of the research group. In other words, the age-specific death rates in the United States are multiplied by the number of persons in the corresponding age categories of the research group. The sum of these products is the expected number. The ratio of the expected number to the actual number multiplied by the death rate in the research group yields the age adjusted U.S rate.

TABLE IV

Deaths in Research Group and General Population[a]

Rank in U.S.	Cause of Death	Number of deaths (research group)		Rate per 100,000 per year	
		Actual	Expected	Research group, 1955–60	U.S., 1958[b]
–	All causes[c]	25	49.8	238.3	474.8
1	Cardiovascular diseases	17	21.9	162.1	208.8
–	Coronary thrombosis	12	15.4	114.4	146.8
–	Cerebral hemorrhage	1	2.3	9.5	21.5
–	Other cardiovascular diseases	4	4.2	38.1	40.0
2	Cancer	7	8.1	66.7	77.2
3	Accidents[c]	0	7.1	0	67.7
4	Suicide	1	2.3	9.5	22.2
5	Cirrhosis of liver	0	1.5	0	14.3
6	Influenza and pneumonia	0	1.1	0	10.5
7	Tuberculosis	0	0.7	0	6.7
8	Diabetes mellitus	0	0.6	0	6.1
9	Ulcer of stomach and duodenum	0	0.6	0	5.5
10	Nephritis	0	0.5	0	4.8
–	All other causes	0	5.4	0	51.5

[a] General population of white males 20–64 years of age.

[b] Adjusted to the age distribution of the research group.

[c] The probability that the difference in rates would occur by chance alone is less than 0.001.

The average annual death rate in the research group was about one half that in the general population. The mortality of other male salaried employees was also below that in the United States, but was 71% of the national rate. (Table V.) The breakdown by cause of death, shown in Table IV, clearly indicates that the highly favorable over-all mortality rate of the research workers is not found in the two major causes of death, cardiovascular disease and cancer, which accounted for all but one of the 25 deaths. For these two disease categories combined, the death rate in the research group was only 20% below the rate in the general population.

TABLE V
Comparison of Death Rates in Three Groups

	Rate per 100,000[a]	Ratio to U.S. white males
Research group	238.3	0.50
Other male salaried personnel	336.2	0.71
U.S. white males, 1958	474.8	1.00

[a] Age-adjusted.

The cancer death rate differed little from the national rate; there were seven deaths compared to the expected 8.1 Two of these deaths were due to cancer of the lung, and one each to cancers of the stomach, colon, larynx, testis, and skin (melanoma).

The absence of any deaths due to accidents is especially noteworthy. If nationwide rates had prevailed, there would have been seven such deaths during the six-year period. This fact coupled with the significantly lower incidence of absenteeism due to accidents, noted in the previous section, suggests that the research workers are less susceptible to accidents than are other persons.

Summary and Conclusions

The data we have assembled provide substantial evidence that our research workers are, on the whole, in a better state of health than most American males of the same age. Their illness and death rates were found to be, respectively, 43 and 50% of that in the U.S. population. There is also some evidence which suggests that they are healthier in certain respects than other male salaried employees in the Company.

With regard to individual diseases, the research group we studied showed excessive attack rates for only one illness category, respiratory infections, but this was probably due to the vagaries of the influenza epidemic that occurred during the study period. On the other hand, there is almost unequivocal evidence that the

research workers are less susceptible to accidents than are other men in the Company and in the general population. This is borne out both by illness and death rates.

Less encouraging is the fact that the research group, although in a slightly favorable position, does not differ too greatly from other American males in mortality from diseases of the cardiovascular system and cancer, the two leading causes of death among middle-aged men. However, there were no deaths in the group from other diseases, most of which, unlike the two just mentioned, are of the kind that can be prevented to some degree by good nutrition, proper hygiene, and by following the standard rules of health maintenance.

In this connection, mention should be made of the part played by the du Pont Company's medical program, carried out by a large staff of physicians, nurses, and laboratory technicians. All employees are given complete physical examinations annually, and some may be seen more frequently for consultation purposes. The main objectives of the program are the prevention and early diagnosis of disease. If an illness is detected and treated at an early stage, the disease process may be arrested, its progress slowed, or its severity reduced. A preventive medical program of this type yields dividends in the form of reduced sickness absenteeism and mortality.

The lower incidence of preventable causes of disability and death among research personnel suggests that their beneficial environment, both at home and at work, their above average intelligence, and the medical facilities available to them may be the major factors that contribute to their favorable morbidity and mortality experience.

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1. U.S. Department of Labor, *The Monthly Report on the Labor Force*, Washington, D.C., Jan. 1956 to Dec. 1958.

2. U.S. Department of Health, Education, and Welfare, *Vital Statistics of the United States, 1958, Volume I*, Washington, D.C., 1960.

THE DEVELOPMENT OF MARLEX*

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INTRODUCTION

Your discussion leader requested that I present to this study group a brief account of how Phillips Petroleum Company translated its high-density, linear polyethylene research discovery into a commercial process. The elapsed time from start of development of the program to successful operation of a commercial facility turning out marketable polymer was slightly less than three years. For those of you who may not be too familiar with the plastics field, Phillips' polymerization process to produce high density polyethylene plastics, trademarked Marlex, was the first to be developed by an American firm. It makes polyolefins which are stiffer, harder, less permeable, higher melting, and of higher density than the polymers produced commercially by the high pressure process. This pioneering project, with its supporting facili-

* A case history presented at the IRI study group conference on Expediting the Transition from Research to Production, February 7–8, 1961.

† C. Keith Buell has a Professional Engineering Degree in Petroleum Refining from Colorado School of Mines. His entire professional career has been with the Phillips Petroleum Company. Starting as a Research Engineer in 1939, he subsequently filled various research and development and plant technical and administrative positions. In 1951 he was appointed Manager of Process Development Division of Research and Development Department. He has made numerous contributions to fields such as hydrocarbon and chemical separations, motor and aviation fuel, synthetic rubber, and plastics.

ties, comprised the largest single undertaking in the history of the Phillips organization.

Before highlighting some of the complex interrelationships among the many groups involved and the various means taken to expedite the translation of this discovery to commercial reality, it is necessary to say a few words about the organizational structure of Phillips' Research & Development Department and its relationship to corporate management. Also, to place the subject under discussion in proper perspective, a brief overall look at our company would seem to be in order since any company's research and development organizational structure must necessarily be related to the company's size, objectives, and needs.

Phillips is the 16th largest industrial corporation in the United States. Its assets total some $1.6 billion. It is 8th in size in the oil industry. Crude oil production and processing, natural gas, natural gas liquids, and chemical operations are closely integrated. Its diversified line of products includes crude oil, natural gas, natural gasoline, aviation gasoline, jet fuels, fine chemicals, synthetic rubbers, liquefied petroleum gas, ethylene, benzene, ammonia, nitrogen fertilizers, furnace carbon black, solvents, plastics, materials for synthetic fibers, diesel oils, motor fuels, and lubricating oils.

Research and Development Department Organization

Our management believes the best way to assure that its research and development work will be effective is to organize the department as a separate, centralized unit reporting directly to top management. Further, that industrial research and development must bring together all activities necessary to derive, unfold, and evolve an idea into a profitable achievement. Thus, our research and development department comprises five different but interrelated activities, organized as closely knit divisions within the department. These are Research, Patent, Process Development, Market Development, and Administrative Division, all grouped

together at our company headquarters in Bartlesville, Oklahoma. Administratively, these divisions are separate entities because effective performance on their part requires men who not only have different and specialized scientific training but also have different professional interests. Thus, authority and responsibility for results are placed in a unified and centralized organization equipped with facilities and manpower necessary to carry an idea from its inception to commercialization. The Department has some 1,000 employees exclusive of those on Atomic Energy Commission projects.

The Research and Development Department is headed by a Vice-President who reports directly to the President of the Company. This Vice-President is also a company director. A Department Manager assists the Vice-President in his duties.

The activities of the Patent, Market Development, and Administrative Divisions are well recognized. However, considering the topic under discussion, it may be helpful to clarify the relationship between the Research and Process Development Divisions. The former is primarily concerned with fundamental research and basic problems relating to the development of new processes and products and to finding improvements of and better uses for new and existing products. This Division conducts laboratory and bench scale experiments and acts in a consulting capacity on technical matters for the other departments and for Management. The Process Development Division's primary responsibility is to help bridge the engineering gap between research and commercial production. It is responsible for design, construction and operation of new product and process development pilot plants, process design and evaluation of contemplated or authorized commercial plants, development and construction of special mechanical equipment, and development and application of advanced process monitoring and control instruments. The Process Development Division also furnishes specialized engineering assistance and services to the Company's operating departments and special assistance and process designs to Company licensees.

Development of the Marlex Polyolefin Process

Against that background, the Marlex polyolefin process development program can be described with particular emphasis on the ways and means taken to accelerate the commercialization.

At the outset Phillips recognized that a great many new and difficult challenges would have to be met and mastered, particularly since the Company had not heretofore engaged in plastics manufacture. The process itself would have to be translated from small bench-scale reactors to continuous commercial equipment incorporating much new technology. This translation would necessarily involve investigating and evaluating many alternate process steps and equipment types. There were problems of mixing, solids handling, solids drying, distillation, fluid flow, heat transfer, extraction, adsorption, fluidization—in short, virtually the whole classic list of unit operations. Since the process would undoubtedly be rather complex, new process monitoring and control equipment would have to be developed and constructed. New analytical techniques would have to be developed. Basic improvements from continuing research activities would have to be incorporated from time to time. Fairly large quantities of the new plastic materials would be needed for experimental evaluation and market development purposes. Commercial plant design factors would have to be obtained, and engineering designs and economic evaluations of commercial facilities would have to be continually projected as the process and market development work unfolded. Commercial plant operators would have to be trained in the pilot plant. Technical assistance would have to be provided for initial plant start-up. A sales organization would have to be trained and a complete sales service laboratory would be required in advance of starting commercial production. In many cases, new techniques and tools would have to be provided to fabricators to convince them of the profitability of adopting Marlex plastics. Concurrently, if the market potential turned out to be as big as we hoped, no one manufacturer could expect

to satisfy the market and the process would be licensed, which would involve much technical assistance to others on design of their commercial facilities. (As an aside, it developed that within two years after Phillips management decided to commercialize the process, eight major companies became licensees, which required quite a bit of the time of some of our key technical personnel.) And paramount of course, top management would have to be rather frequently apprized of progress to convince them of the merits of the project, thus making certain that neither manpower nor dollars restrictions would slow it down.

The first major management decision was that development work should be undertaken. It was made only after evaluation of laboratory and bench-scale research work indicated that attractive commercial possibilities existed, and, in the judgment of our development engineers, the probability of successful scale-up to commercial plant was high. The results of market research indicated that the potential was good. Preliminary engineering economic studies indicated that the project should be commercially attractive. Finally, the project conformed to broad company policies and objectives.

Following the decision to take the research work into the development stage, our first objective was to design and build pilot plant facilities based on research findings and very preliminary process design studies. The unit would initially serve two purposes — (*a*) to develop the individual process steps, and (*b*) to furnish polymers for initial market evaluation. Several basic premises were established to speed the process development:

(*1*) A workable process with reasonable economics would be developed for the first commercial unit. Attainment of optimum economics would follow and be incorporated in subsequent commercial units.

(*2*) Wherever possible, commercially available types of equipment would be used to avoid time consuming development and fabrication of special apparatus.

(*3*) Where possible and feasible, special process equipment

would be rented for testing in the pilot units to cut capital outlay and speed results.

(*4*) Alternate processing routes would be investigated simultaneously on some of the more difficult steps to improve possibilities of rapid success.

(*5*) A special group of chemical engineers would be organized to handle each of the major process steps. This would allow development to proceed simultaneously on each step.

(*6*) As indicated in Items (*4*) and (*5*), the initial pilot plant facilities would be non-integrated. This, of course, was intended to preclude development work on any upstream unit operation holding up progress on downstream unit operations.

Small working-level groups of research chemists and process development engineers in their respective fields of interest and responsibility met frequently to help assure perfection of communications and team work between laboratory, pilot plant, process design and evaluation groups, and others. Chemists and other scientists were assigned the responsibility of checking the quality of polymers produced by the pilot operations and for the basic studies to improve the catalyst. The pilot plant process development engineers provided new information and tested new operations. Process design and evaluation engineers continually evaluated the information in terms of projected commercial plant designs and economics, pointed up areas where more data were needed, and suggested possible improvements and modifications that should be investigated by the pilot plant group. Every step of the way our engineers were instructed to keep in mind the economic facts of business life. The best solutions to problems were those that paid off.

Efforts along the foregoing lines proceeded for one year. During this time most of the pilot plant operations were standardized, at least to a sufficient extent that toward the latter part of the year the unit operations could be integrated such that a reasonable amount of Marlex polymers could be produced, albeit by brute force. Sufficient selected polymer having properties within the

range considered to be most desirable, based on Research Division product evaluation, was accumulated in one large blended batch and made available for field evaluation by a number of plastic fabricators in small-scale production test equipment.

Thus, at the close of the first year of pilot plant work, the process development had reached a stage where sufficient information was available for the design of most steps and for a reasonably accurate estimate of construction and operating costs. This rather definitive engineering-economic study appeared highly encouraging as did also the limited market evaluation. At this juncture, assurances were given to top management that although a number of scale-up problems and market development problems still existed, acceptable solutions appeared to be shortly forthcoming, and the technical and market evaluation groups recommended and obtained management approval to build a commercial facility. Although complete design information was not available, management requested that mechanical design work on the first unit be started immediately on those parts of the process that could be frozen with final design freeze date set for five months later.

With definite management commitment to a commercial plant, the objectives of the pilot plant work then became (*1*) to obtain sufficient technical information to make remaining process decisions, (*2*) to supply design data to meet schedule of design freeze dates for individual sections of the commercial plant over the next five months, and (*3*) to produce larger quantities of finished Marlex polymers for full-scale market development test purposes.

In connection with the latter item, it was apparent that the then existing pilot plant facilities were inadequate to fill the needs of market development and still continue process development and improvement studies. Thus, the building of a new integrated semi-works plant having a capacity of 1,000 pounds per day was authorized. In addition to providing the required expanded production and freeing the original pilot plant for experimental purposes, the semi-works plant provided valuable operation experi-

ence and training, and later served as a demonstration unit for process licensees. To expedite its construction, two of our Company's mechanical engineering design men and two of our pilot plant engineers were located at the plant site, and design and construction proceeded simultaneously. Top priority was given to expediting equipment procurement, and equipment was installed and piped together largely by simple line drawings and verbal instructions. Although the semi-works unit cost well over one-half million dollars, it was turned over to pilot plant personnel for operation in less than five months from the date of authorization. It continued to supply market evaluation and development polymer until our first commercial facility was placed into successful commercial operation.

During this stage of our activities in process and market development and pilot plant, project manpower obviously had to be increased considerably. Shortage of qualified trained personnel dictated spreading the engineering staff as much as possible, and expansion was achieved by a modest increase in technical personnel which was partly supplied by temporary transfer of process engineers from Phillips Chemical Company, along with a steady increase in the ratio of supporting nontechnical personnel. Progress in this direction is shown by the fact that at the time pilot plant work was first initiated, the ratio of nontechnical to technical personnel in the pilot plant group (exclusive of maintenance, warehouse, and shop supporting facilities) was approximately 1. This was rapidly increased to $1^1/_2$ during early stages of process development, and reached as high as $3^1/_2$ at the peak of the program when the semi-works unit was in operation along with the pilot facilities.

Before the commercial plant began operations, a startup committee was organized composed of Phillips Chemical Company operating personnel and Research and Development Department people. Its purpose was to guide the startup operations in such a way as to take full and speedy advantage of all the experience available within the Company and to maintain continuous liaison

between research, development, and operations. Several key positions in the operating organization were filled by individuals transferred from the pilot plant. When the large plant approached normal operations, temporarily assigned pilot plant men returned to their former activities. During this period, process and operating improvements resulting from commercial plant experience and concurrent pilot plant activities were quickly incorporated in the commercial plant. Close liaison made swift action possible. Thus, 33 months after starting the development program the commercial plant turned out marketable polymer. Three months later the first unit reached design capacity.

During the commercialization step, herein defined as that time between management decision to develop the process and time of first commercial production, other ways and means than touched on heretofore were used to expedite the project. They were of considerable importance, but they will only be discussed briefly.

We believe that research and development professional groups will function most effectively when they are relieved of service functions so they can be free to concentrate on their primary responsibilities. Considerable effort was expended to give our engineers and scientists adequate support by way of maintenance, materials procurement, and shop services with a minimum of effort or time on their part.

Where possible, statistically planned experiments were used and electronic computors employed to free our engineers for more creative work.

Our Instrumentation and Automation Branch was brought into the picture at an early pilot plant stage. Thus, advanced process monitoring and control instrumentation was developed and de-bugged right along with the development of the process steps.

Our Patent Division was furnished copies of the process design flow sheets and other information pertaining thereto as the design progressed from preliminary to final stages. Thus, when the project reached the commercial plant appropriation request

stage, patent personnel had sufficient background and time to advise on the patent status with no time delays.

The operating organization, in this case Phillips Chemical Company, was brought into the picture as soon as possible. Their technical personnel were kept continuously apprized of all significant research and development activities, and they assisted in the design and economic evaluations. This helped speed up transfer of complete technical background and know-how to the operating entity who would have responsibility for the commercial plant investment and operation as well as provide full opportunity to incorporate their latest operational know-how into the research and development designs. Also, of course, it assured that no undue time delays would be encountered in convincing the operating organization's management of the project merits before they and Research and Development Department jointly requested top management approval to commercialize.

Periodically, during the course of this project, the company's executive committee was given a verbal review of market outlook, status of research and process development, patents and licensing, raw material supplies, and economics. These presentations by our key technical-administrative personnel produced two results. They provided direct communication with top company management—giving them accurate reports on which their decisions could be based. The other less obvious result was the enthusiasm developed through the project itself. Knowledge that our top management had enough interest to have these report sessions proved to be a real stimulus to greater effort through the ranks of the project.

Finally, and all important, we must give major credit for any success we had in speeding up this multi-million dollar project to the encouragement, receptiveness, and foresight of our top management, and particularly to their courage in making fast and favorable decisions on somewhat limited facts.

PROCEEDINGS OF INDUSTRIAL RESEARCH INSTITUTE STUDY GROUP MEETINGS. NUMBER 5. IMPROVING THE TECHNICAL COMPETENCE OF RESEARCH WORKERS*

STAFF REPORT

INTRODUCTION

What is technical competence? The concept is elusive of definition, but its importance is manifest in various ways as, for example:

The ability to define a problem and subdivide it into logical components.

The application of knowledge to the solution of a problem.

Skill at devising experimental approaches and making precise measurements.

Ability to organize and interpret data, and discern relationships indicated by the data.

Skill in communication.

Knowledge of the literature, and ability to conduct searches.

Persistence in working at a problem until it is solved.

Ability to discover a new principle.

Foresight in visualizing the practical applications of research results.

* Two conferences on this topic were held at IRI Headquarters in New York City; one on February 2–3, the other on March 1–2, 1960. The participants, of whom there were 17 at one session, and 18 at the other, were drawn mainly from the top two levels of corporate research management. The discussion leaders at the first session were Dr. Carl O. Tongberg, Executive Vice President, Esso Research and Engineering Company, and Dr. William E. Han-

These and similar skills are rarely, if ever, found in one person. However, this premise was basic to each meeting: The qualities which, in the aggregate, constitute the scientist's technical competence are susceptible of improvement during the course of his career, and particularly is this true for the early stages.

The problem before the conference was twofold.

(1) To discuss the motivating forces within a person which urge him on toward increased competence.

(2) To determine and evaluate the external elements which provide the same motivation.

A corollary to the discussion was the determination of factors which exert an inhibiting influence.

The distinction between forces within the person and factors which are external is a convenient one, but the distinction is not sharp because most of the elements which make up individual motivation are influenced by environmental factors, and these factors cannot be studied apart from the persons involved.

Incentives for Improvement

Motivation Toward Company Interests

A participant at one of the conferences, himself a director of research of a well-regarded organization, pointed out that the young scientist on leaving the environment of a university for an industrial career makes a difficult transition of critical importance to himself. At this stage, his determination to achieve success, his ability to learn, and his motivation are at a high level. At this time also, he is most sensitive to influences—one of which is neglect—which can hinder his development. Efforts directed at the in-

ford, Vice President for Research, Olin Mathieson Chemical Corporation. The second conference was led by Dr. Tongberg alone. The circumstances which led to the formation of these Research Management Study Group Conferences, and their objectives are covered by Vaughn in *Research Management,* III, No. 2, 93 (1960).

crease of technical competence should therefore start at the time that he reports for duty.

The young scientist is motivated toward his career, his profession, and his company; the relative importance assigned to each varies with the individual. Whatever his outlook, it is obviously desirable to achieve an identity of these three objectives. One way of doing this is to clarify the corporate goals to the man and relate them to his professional career. When this is accomplished successfully, he identifies his own interests with those of the company and profession. The three objects of his motivation fuse into one, and the stage is set for him to exert his best efforts.

Encouragement

One of the research directors outlined his procedure for encouraging a sense of identity between the objectives of the newly arrived scientist and those of the organization. He makes it a policy to have an interview with the man when he reports for duty. They may have lunch together, and this meeting affords an interchange of views; questions are asked and answers given. As a result, the scientist feels more at home in his new environment. He has evidence that the director is interested in his welfare and in his work. After six months of service, the director invites the man to his office for a fairly extended conference concerning the progress he has made, the difficulties he has encountered, and the experiences he has had. Questions are again raised and answers given.

The man leaves the conference with a sense of appreciation for the personal interest of the research director. He has a better understanding of his place in the organization, and of the opinions that others have of his work. The conference is repeated at the end of a year when the matter of a merit increase arises.

The director stressed these beneficial effects of his procedure: Each newcomer develops a sense of identity with the organization. He is assured that the management echelons have personal inter-

est in his work and in his development. High morale is encouraged. In addition, the research director becomes more intimately acquainted with the detailed work of his own organization for, as he stated, the conferences provide information which he does not get through other channels. This phase of his activities has indeed produced gratifying results, well worth the time and effort devoted to it.

Curiously enough, the bench workers in quite a few organizations do not have knowledge of their relative standing. Depending upon personal traits, some persons do not object to that state of affairs, while for others it is a matter of worry and even resentment. Most companies attempt to resolve the problem by use of personnel appraisal systems which are a means of acquainting a man with the supervisor's assessment of his qualities and his work. Such appraisals were discussed in Proceedings No. 3, "Selection and Placement of Research Personnel," *Research Management*, IV, No. 1, 43 (1961). However, the informal conferences between a bench worker and the research director or other supervisors are a supplementary, and possibly more effective means of establishing mutual understanding.

It was mentioned earlier that the young scientist making the difficult transition to industrial research is at a high peak of the curve in his determination to make good. At this stage, he is also unusually sensitive to external influence which, in one way or another, exert their effects. It is beneficial to the man and the organization to increase his confidence in himself. Kindness and understanding are needed. A quick or impatient reaction on the part of a supervisor to a suggestion of the bench worker can have a prolonged, serious influence upon his morale—an effect far beyond the importance of the original idea.

In order to minimize incidents of this type, one participant stated that his organization utilizes an IBM system to obtain reports on specific subjects. By this means, a man can satisfy himself whether or not any work has been done along the lines of his ideas. This is a straightforward system which provides a factual

basis for the prevention of misunderstanding or duplication of effort, and constitutes an important influence toward contributions which are indeed original. The effective retrieval of past reports has proven to be a valuable instrument of control and guidance, both to management and bench worker.

Another provision which causes a bench worker to have a greater feeling of attachment to his organization is the assurance that his supervisor does not constitute the only court; that he has the right to present his case before others in authority in the event of a dispute.

Competition and Cooperation

The successful conduct of research programs is dependent upon cooperative effort among men of the same and different disciplines. Along with the indispensable element of cooperation, there is present a natural, inevitable spirit of competition among personnel of similar skills. These two forces—competition and cooperation—can become mutually antagonistic. It takes a high order of leadership to bring about a wholesome level in the competitive spirit, thus keeping it in proper balance with that mutual and willing assistance, the informal give and take which is a basis of success in organized research. The understanding supervisor who knows his men, and gives credit where credit is due, is a major factor in achieving an optimum balance between the two forces.

Most scientists take the competitive spirit as a spur to greater accomplishment. However, there are others who consciously endeavor to discover in it the minimum standard of performance which will be rated as satisfactory. That standard will vary with the caliber and competence of the technical staff. Persons of marginal ability tend to lower the average level, and those who are satisfied merely to drift along will govern their efforts accordingly.

That is the reason given by a participant for his company's resolute policy of terminating those whose work has proven to

be marginal or unsatisfactory. One result of the practice is an increase in the average level of competence, and those whose goal it is to keep up with the average find it necessary to raise their sights accordingly. The policy of termination for unsatisfactory performance applies not only to the young scientist, in the organization for two or three years, but also to considerably older men with a decade or more of service whose work has deteriorated. This company has found that in many cases the termination has a beneficial effect also upon the persons involved, for the shock, the rude awakening, which results from the experience, brings home to the man the facts of his situation. He faces up to the reality and finds a new job to which he applies the full measure of his competence.

Along the same line of thought, the presence in the organization of persons of superior creativity, competence, and diligence is an inspiration and incentive to others, particularly when it becomes evident that such persons are suitably rewarded for outstanding achievements. Thus it may be seen that a company can properly utilize the natural and inevitable spirit of competition among its personnel to raise the level of technical competence not only of those who have a tendency to keep up with the average, but also of the men who seek to emulate the best.

Requirements of the Research Problem

Another potent incentive toward improvement is the inherent technical requirements of the research assignment. When the successful resolution of a problem demands effort and knowledge additional to that which the incumbent already has, he will generally take the necessary action to meet the challenge. In practice, the supervisor must assign problems which, while challenging, are not overwhelming. His skill in the exercise of this function can have a markedly beneficial effect on the development of the bench worker. Here again is an instance where the natural inclinations of a person can be strengthened by organizational

factors, among which are the existence of problems of suitable complexity, the skilled supervisor who can make the proper assignments, and the availability of library and other facilities which provide the means for improvement of his knowledge and skill.

Intellectual Curiosity

A man who is accepted into an organization in the capacity of a professional research worker can generally be expected to have a substantial level of intellectual curiosity—that quality which impels him to seek out the cause of phenomena, to control their effects, and to discover new applications. When the trait is combined with a high degree of motivation toward the company, and a confident feeling that his work will be recognized, the conditions are attained whereby the man does not govern himself by the regular hours of employment for he can be found at work during those hours as well as weekends and at night. The company that succeeds in achieving conditions which permit the satisfaction of intellectual curiosity is quite often the one that is assured of future growth by the development of new and better products.

Furtherance of Education

The general but not universal practice among the companies represented is to pay the tuition charges of those who take technical courses of study either during or outside of regular working hours. In addition, quite a few organizations make arrangements with qualified instructors to give specific courses on the company premises. One organization in the communications field provides a three-year course of study during regular working hours. It extends through the academic year and runs for three days per week during the first year, two days weekly for the second year, and one day in the third. The instruction during the first and second years is given by a university under contract. This very

elaborate and expensive method of training has been found desirable for those below the master's level because the employees acquire necessary knowledge and skill in the electrical and allied fields which they did not receive in their undergraduate studies. In addition, this same organization offers highly specialized and advanced courses which are given by its own personnel.

There is an increasing trend toward the granting of sabatical leaves for study at a suitable university abroad. Such opportunities are generally given not only to improve technical competence, but also in recognition of the present status of appointees, and as a reward for their past achievements.

One large organization offers courses which may be of two-weeks duration, during regular business hours, in such fields as physical organic chemistry, reaction kinetics, and statistical methods. The instructors are generally university professors who work under contract with the organization. Attendance at a course is voluntary and when more persons desire to attend than can be accommodated, the department heads make the selections on the basis of quotas allotted. Each course is followed by a written examination.

The company-sponsored courses of study are not limited to those of specific technical interest. Subjects in public speaking, reading skill, and report writing are also offered. There was considerable discussion regarding the value of these courses to the company and to the employee. One participant stated that encouragement of course work, particularly during regular working hours, tends to build a type of professional student who is unlikely to make real contributions in research. Others were definitely of the opinion that a well-motivated scientist uses the courses as a tool which enables him to do work of higher caliber.

One large and successful organization adheres to the policy that a man who wants to further his formal education should have the motivation to do so at his own expense. That principle may, be modified however, because of the developing trend toward the contrary view by competitors.

Several companies have sent men to management courses with results which varied in the extreme. Some men were benefited while others were very adversely affected. There appeared to be a consensus that management school is no place for a man who enters without native managerial traits which can be developed.

Seminars

Several companies represented at the conferences have a practice of engaging outstanding men to deliver talks at seminars of the technical staff. Foreign scientists who happen to be in this country are on occasion invited when their fields of interest are related to the company objectives. The fees generally range from $100 to $200 per day plus expenses. In practice, the speaker and the subject of the seminar are made known in advance. Questions are asked in the discussion which follows the prepared address. The speaker is generally available for informal conferences during the remainder of the day. In activities of this kind it is always difficult to give a precise evaluation to the results of the visit. However, agreement was general that the opportunity to hear an outstanding man, to make his acquaintance, and to engage in discussion with him has a stimulating effect upon the technical staff, and is a significant element of encouragement toward improved technical competence.

Of more frequent occurrence than the engagement of outside speakers is the practice of holding seminars in which all the participants are members of the company's technical staff. One or more scientists are chosen to make presentations concerning their current work, and a period for questions, answers, and comments follows each talk. These meetings are an effective way to disseminate knowledge of current work among those concerned. Several persons observed that seminars can have increased value if more discussion followed each talk. This is not easily accomplished, for some persons have a native reticence or embarrassment at presenting comments or questions in public—even the limited

public of an internal seminar. The feeling tends to be overcome by the encouragement of an atmosphere of friendship and cordiality in which any suggestion of personal criticism is excluded. Some organizations have the seminars at informal dinner affairs, during which the optimum atmosphere is more readily achieved.

Another obstacle to full discussion is the difficulty of assimilating the details of a technical presentation during the brief time that it takes to deliver it. Many persons hesitate to ask questions, the answers to which might be obvious by a closer study of the presentation. The factor can be minimized through careful preparation not only by the speakers, but also by the audience who might receive an outline of the talk in advance.

In addition to the seminars, the encouragement of informal, unscheduled conferences among persons of whatever echelon, one having a problem, the other possessed of needed information or advice, is a most effective means of promoting accomplishment. One organization makes known to its personnel the policy that anyone has the right to speak to anyone else who, he feels, can help him in his work.

Consultants

Many of the companies represented utilize the services of consultants on a part-time basis. One person was dubious of their worth to an organization, but the consensus was that consultants with suitable professional and—equally important—personal qualifications are a source of stimulation, even inspiration, to the technical staff. The feeling was that the greatest value accrues from the services of consultants who are outstanding in theoretical fields.

In a typical organization, the consultant works under a one- or two-year contract which is renewable. He visits the laboratory at regular intervals for one full day during part of which he has a formal conference with the director of research or other persons on subjects which were selected beforehand. For the remainder of the day he is available to members of the technical staff who

desire his counsel. During this time the consultant who visits the man at the bench is more appreciated than one who stays at his desk.

In addition to the help in technical matters, the use of consultants has a significant effect upon recruitment. They are in many cases well-known university professors who are in a superior position to advise students regarding employment. One gained the impression that some companies regard this incidental aspect as a governing factor in their continued use of consultants' services.

There are laboratories which have scientists of high professional standing among their personnel. These are the people who have chosen the scientific as distinguished from the administrative ladders of advancement. Such men frequently act in the capacity of internal consultants in addition to their regular research work. The presence in the organization of eminent co-workers is a source of inspiration to the younger colleagues who consciously endeavor to match their achievements.

Factors Which May Inhibit Improvement

Publications

The strong motivation of the scientist toward his career and profession always carries with it a definite urge toward original contributions which he would like to have appear in scientific journals. In the case of an organization that has a section devoted to basic research, the results are mostly of such a nature that publication in a journal is desired, both by technical man and Management. The scientific reputation of the company is enhanced along with that of the person who conducted the work, the company gains fundamental experience along lines which may lead to application in the future, and proprietary rights are not a governing factor. However, a great majority of industrial scientists are engaged in applied or development work, the results of which can be disclosed only after a prolonged delay which is necessary

to enable the company to reap the full competitive advantage. Investigations in the development and applied fields may lead to patents which certainly are one form of publication, though restricted in distribution. Between patents and papers suitable for journals of pure science, there is a spectrum of contributions that may be suitable for periodicals of applied science, and within this range matters regarding publication arise which quite frequently become a bone of contention between the technical man and the company. The organizational policies regarding publication of results have been the cause of bitterness and dissension in some companies. Others with substantially similar policies have gained general understanding and acceptance because valid reasons were give in explanation of the policies. The participants at one of the conferences agreed that the difficulty is one in which effective communication is heavily involved, but the subject required more discussion than could be allotted to it.

The Older Bench Worker

Since the end of World War II, the national research and development effort has increased at a rate that is without precedent. The demand for technically qualified men in virtually all the disciplines of science has outpaced the supply. The vast expansion also created a demand for more people to fill the various echelons of management in the huge research organizations developed. As a general practice, the management positions in the line and some of the staff functions were filled by the appointment of persons who had demonstrated their competence as bench workers and who also displayed qualities of leadership and other abilities. Such appointments involved greater responsibilities, higher salaries, and the other amenities which accompany management. Many scientists who begin their industrial careers as bench workers do so with the conscious plan and expectation that they will receive appointment as managers in line or staff positions after they have proven their competence.

However, with the developing maturity of the research effort, there may be discerned a slackening in the rate of growth of re-

search organizations with a consequent decrease in the need for managers. Those scientists who have set their sights on such positions find that vacancies are fewer, and their jobs at the bench are prolonged beyond their expectations. In addition to those who have the qualities requisite for leadership, but find the opportunities reduced, there are others who, contrary to their own plans and ambitions, do not have the abilities required of a good manager. A condition is thus created whereby scientists remain bench workers longer than they had anticipated, and serious problems have resulted which are not only of a personal nature, but also affect the morale and esprit de corps of the entire research organization.

What can be done about these research workers who feel that their progress has not kept pace with their years? Efforts at improving the technical competence of scientists who are young, and at their peak in the determination to make good, present difficult problems. How much more perplexing are the factors involved in dealing with the older men who are more set in their ways, who have to work much harder to assimilate new learning, and who see little to compensate them for the extra effort. The problems, which have been treated very briefly in this discussion, are more numerous than the present-day solutions which include effective appraisal, rotational training, proper encouragement, promotion via the technical ladder, sabbatical leave, and stimulation of technical interests. All of these are potentially useful. However, as one participant observed, the time has arrived for serious and expert study.

Incompatibility

While the conferences were concerned primarily with improvement in the technical competence of the individual, it was recognized that he could not be considered apart from the group or team of which he is a member. Several persons observed incidents where a man does very satisfactory work in a team, and later, for reasons of personality, the nature of the problem assigned, or for other causes, his performance drops markedly. This same per-

son, when reassigned to a different group will often show rapid and sustained improvement in his work. There are cases where the native human inertia poses obstacles and resentment against reassignments which, when they are finally made, prove beneficial to all concerned. The various factors involved are usually subtle, subjective, and possible of discernment only by those with experience and skill and resolution in leadership. This is one of many examples which illustrate that skilled supervision is one of the most effective of methods for the accomplishment of better work.

The Viewpoints of Bench Workers

One executive of a large research and development organization discussed with a selected group of bench workers the conditions and factors affecting the quality of their work. The following observations were made:

Bench workers should participate in a problem from the very start, including the preliminary discussion phases. Complaints were voiced that on occasion, a garbled version of the problem was received from the supervisor, which delayed progress of the work.

During the course of an investigation, managerial control should be as light as possible and formal organizational structure minimized. In this connection, the importance of the supervisor was again stressed. If he is a skilled leader, his control will be light, yet helpful. His encouragement is needed. Some bench workers stated that certain supervisors are more of a hindrance than a help.

Library facilities are an indispensable part of the resources for research. Use of the library should be encouraged and not regarded as a convenient means of passing the time.

A truly professional atmosphere in the laboratory should be fostered, and cliques or group status discouraged. Communication should be easy and informal, opportunities for discussion with consultants frequent, and attendance at technical meetings encouraged.

Investigative work by its very nature presupposes that mistakes will be made and management should recognize this.

A man does better work on a problem in which he has personal interest and aptitude. That fact should be considered when making assignments.

If it is conceded that the top motivating force of most industrial people—including industrial scientists—is money, it is also recognized that other elements exist, among which individual recognition and esteem stand high on the list. When a team completes a project successfully, the members expect commendation. However, outstanding work by an individual in the team should be recognized and that person suitably rewarded. A man will exert the full measure of his competence when he knows that top management is interested to find out who does the good work and reward him accordingly.

A man whose performance is consistently unsatisfactory should be discharged.

The well-motivated scientist works hard at a problem and has a keen interest in the subsequent development. It is discouraging to complete an "urgent" problem successfully only to find that no use is made of the results.

The caliber of work in a laboratory is improved when its personnel are drawn from different institutions. Widely varying outlooks are conductive to more ideas and greater vitality in the organization.

These views of bench workers in a research and development laboratory are very interesting and worthy of study. The expressions of the conditions which help to make the ideal environment for creative effort cannot be regarded as conclusive; indeed, close examination may reveal inconsistencies in the measures advocated. However, the executive charged with the responsibility of achieving the highest quality possible in the research work of his organization should give full attention to all echelons in his organization before decisions are made on policies and courses of action.

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THE PROFESSIONAL COMMITMENTS OF SCIENTISTS IN INDUSTRY

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Ever since the scientist became an industrial laboratory employee in large numbers, he has become an object of interest and scrutiny. He has been written about by novelists, psychologists, and journalists. Many generalizations are based on the assumption that he is peculiar and different. The results have provided interesting and even amusing reading, but have thrown little light on him as an employee. I would suggest that it is as an employee that he is of interest, and it is as an employee that I wish to examine him.

The peculiar thing about the scientist as an employee is that his training does not prepare him to be an industrial laboratory employee. He is trained to be a member of a profession who engages in research. That is, he has internalized the values of his profession as to the importance of scientific achievement and the necessary methods of work for such an end. These commit him to a scientific and professional ethos regardless of the goals of his industrial employer. In other words, he is not prepared to be an industrial employee.

My thesis is that since he is not prepared to be an employee, the industrial laboratory must undertake to make one out of him.

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How it accomplishes this is reflected in the particular managerial and personnel problems one finds in industrial laboratories. I want to look at this a little more closely by examining the problem-producing characteristics of the industrial laboratory which affect the molding of the scientist into an employee.

Recruitment

The university recruit is selected by the industrial laboratory both for the judgments about his competence and his future promise. He entertains visions of himself exploring the unknown and startling the world with his breakthroughs into the secrets of nature. The laboratory's recruitment process does not substitute more realistic expectations. Typically, the recruit enters the laboratory with the self-conception of himself as a professional scientist whose future will be largely dedicated to basic research. The industrial laboratory has the objective of adapting him to industrial research employment while at the same time not entirely destroying his self-conception. If this were begun in the recruitment process, the problems of adaptation would be lessened. If, however, the laboratory does this with too much vigor the man may be lost. The laboratory, therefore, postpones the day of realistic induction, and thereby contributes to its future problems. The only other alternative the industrial laboratory has is that of selecting scientists who, with a high degree of certainty, will fit into industrial employment. This, too, has its problems, since competence may not always be correlated with this adaptability.

Career Adaptation

The industrial research laboratory has fairly immediate tasks and goals which are vital to it as an ongoing economic enterprise. To meet its goals, the laboratory has developed an elaborate and expensive organization providing its research employees with all the necessary facilities.

The goals of the corporation are omnipresent. Once in the laboratory the recruit quickly discovers that his expectations need reorganization. As he sees it, initially he is engaged in changing the laboratory. In actuality, he adapts to the requirements of the work situation. In adjusting to his new role he goes through a process of change that permits him to internalize selected aspects of his new environment.

In the process of adaptation four types of career pathways emerge in the laboratory:

(*1*) He may remain devoted to research and a scientific professional career and shape his career goals in this direction.

(*2*) He may become interested in administration and try to steer his career up the administrative ladder.

(*3*) He may be interested in research but turn to administration because he sees a limited financial and status future for himself in research.

(*4*) He may turn to administration because he cannot compete in research with his colleagues.

Career adaptation is productive of strain. It evokes resentment towards oneself and others. The individual scientist may feel resentful towards himself or towards the laboratory for having given up his goals for a high salary, or because he has accepted modification of his self-conception. Awareness of these strain-producing mechanisms and the adequate provision on the part of the laboratory in aiding the scientist's career adaptation would modify the ensuing problems.

Recognition

While the laboratory is engaged in making an employee out of a scientist, what it fundamentally wants to do is to release the dynamo of energy and creativity it has bet its recruit has. What it is really concerned with is motivating him as a scientist toward optimum goal attainment. The key to this objective, I would suggest, is recognition.

Recognition establishes the basis for the much sought after autonomy for the professional person. Recognition provides the scientist with increasing independence in his work. Since, in the final analysis, the scientist's achievement is subject only to the judgment of his peers, recognition is crucial. One might go as far as to say that in science there is a right to recognition. Recognition, then, is not only a basic need of the professional person, it is also a dynamic incentive of paramount importance to him.

The industrial laboratory has introduced a variety of formal systems of recognition, ranging from merit awards to titles. While the introduction of such systems in themselves are productive of strain, the failure to introduce them would provoke greater difficulties. There is no doubt in my mind that the industrial laboratory is valiantly trying to solve its problems of recognition. There is an aspect of the general problem of recognition, however, that is still missing. I refer to the understanding of the scientist's problem of self-esteem as a professional person. This aspect of recognition depends upon the type of authority system within which the scientist must function.

Authority

I have described the type of authority system which prevails in traditional business organizations as *executive authority*. Here ultimate control over policy and over the limits within which subordinates can make decisions rests with top executives and, in the final analysis, with the chief executive. On the other hand, the professions, and especially the academic profession, can be said to be characterized by *colleague authority*. In this system, authority rests in a group of professional colleagues.

The scientist, whether in industry or the university, has need of an authority system which recognizes the characteristics of his professional role. He has need of an authority system which permits him autonomy and protects his self-esteem. He has need of participation in decisions concerning his work.

To meet these needs, the industrial laboratory does grant varying degrees of autonomy. It has instituted varying forms of scientific recognition. It cannot, however, be said to have moved towards a colleague authority system. Its fluidity, however, bespeaks the latent possibility of a new organizational form containing some of the elements of both executive authority and colleague authority.

I want to emphasize that the introduction of a colleague authority system is not a simple matter of enlarging the freedom of the laboratory scientist. It requires extensive skill and expertness in the adequate development of indirect techniques of control. When it is carried out inadequately it arouses resentment on the part of scientists and contributes to conflict. When it is carried out adequately it molds the working environment into what Dean J. Douglas Brown has called a "climate for discovery."

The molding of authority in the industrial laboratory in the direction of colleague authority will permit the scientist to work out new self-conceptions of his role as scientist and employee. It will permit research management to develop new organizational models. This, in turn, will stimulate it to new insights about its managerial inadequacies and assist in undertaking its own change.

RESEARCH MANAGEMENT VOLUME IV, NUMBER 4 (1961)

A MOTIVATIONAL APPROACH TO RESEARCH MANAGEMENT*

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Psychology, the science of human behavior, has developed a considerable body of knowledge, data, concepts, and theories which bear upon problems of the prediction and control of human behavior. As a science, however, psychology has little interest in specifics such as the problems of directing research. It is interested in uncovering basic laws which govern human action. It deals with questions of how we learn, remember, forget. How do we think? How do attitudes form, what is fear, why do we cooperate? All of these have relevance for your work problems, but the transition from general theory to your specific problems of human behavior is too vague to be made in a half-hour address. I could go to the other extreme, and discuss detailed techniques which have already been developed for dealing with specific people-problems which any manager faces. I could discuss testing, or morale surveys, for example.

However, I would be able to speak of only one or two. At best they are of limited value and interest. I would rather bring

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something which might give you more general leverage in handling work problems.

I refer to a psychological perspective, a psychological view of your work. Psychology has provided no specific answers to many of your work problems. I don't even know what some of them are, but my years of training in the theory, method, and content of psychology, coupled with a great deal of experience translating this into practical solutions of problems have produced a problem-solving perspective, which has some merit and which can be passed on in part.

I propose to bridge the gap between psychological theory and your practical needs by giving you a distillation of psychology as it comes out in my perspective.

I want to affect the way you ask certain questions. As scientists, you know the powerful influence the form of a question or definition has on the direction and quality of a problem solving effort.

I assume the best way to communicate a perspective is to show it in as many facets as possible. I don't intend to try to develop a research management theory.

I will talk of the research director's job as a problem of dealing with motivations. I will look at his job as a role in a social-psychological structure. And I will touch upon some problems of individual psychology as they concern the research manager's use of himself as an instrument in carrying out his work.

Let's formulate a definition of the research director's function in motivational terms, instead of in the terms in which it is so often given. Too often, it seems to me, it is defined in terms of a meaning it probably had some years ago when research efforts were developed by individuals, or by small groups. Then, the research director was the scientist who was expected to provide conceptual quality and creative direction to the research program. He directed the thinking of the men whose individual efforts were coordinated into a single attack on a problem. His major concern was research. He functioned as does the typical research pro-

fessor who directs graduate research, or the project director responsible for a grant supported study.

It has been my experience that research directors in charge of centers with hundreds of scientists at work on dozens of problems still may operate with that definition implicit in their approach. They are technical people of high caliber whose excellent research productivity was the basis for putting them in charge of more and more people. They retain their researcher's perspective.

Such a job definition, whether it be explicit or implicit, must blind the director to many aspects of his job which would be considered primary in the light of this motivational definition.

The research director's job is to elicit, organize, and coordinate the activities of a number of individual scientists into a unified effort which will reach the goals of the larger group, the research center or the company. In simpler terms, his job is to get other people to make the actions needed to meet the research center objectives.

You will notice particularly in the motivational definition of research directing, attention is shifted almost entirely to problems of handling people. The research director's main job is to motivate his staff to produce the actions which will move his group to its goals. Let us outline some concepts of motivation and some social psychological concepts about groups which we can apply.

For all practical purposes, there is no such thing as unmotivated human behavior. All human action is taken to fulfill *personal* needs. When a man has a need, he will be motivated toward any goal which will satisfy it. He will be motivated to take whatever action he believes will carry him to the need-satisfying goal. When a man has no need, he will not be motivated and he will not act. When he has a need, but can see no means of satisfying it, he will not act. When he has a need and it is satisfied, he will cease to act. Hold that concept for a moment while we outline the social psychological idea of a group such as a research center.

Such an organized group is a set of individuals working together in various relationships. It is people linked by communi-

cation into a group. The group is more than the individuals in it; it is an entity with its own organizational goals. Organizational goals basically are independent of the personal goals of the people in the group. Typical organizational goals are to produce goods, earn a profit, increase sales, or produce research. In only a minor way do these goals motivate the individuals in the group.

The coordinated activity of individuals moves the group toward its goals. The individual acts because his action moves him towards his personal goals. It follows, therefore, that individuals will work for group goals to the extent the work also moves them toward personal goals which satisfy personal needs.

The group moves to its objectives because a lot of people perform different actions which are tied together and added up to become the larger unit of action, the group act.

Within the group, each person contributes his act to the group act because he expects doing so will satisfy the *personal* needs which are motivating him.

What follows from this for research directors? It follows that the more those actions which serve research center goals also serve personal goals, the more successful the research center will be. When this alignment is close in a group, cooperation, good will, effort, and productivity are high. When the alignment is poor, group activity breaks down. Resulting symptoms are high turnover, unrest, inefficiency, and poor morale.

So what is the research director's job? His job becomes a constant effort to see that what he wants done leads to personal need satisfaction for his people.

With respect to the motivational approach there are two general types of research directors. The first is the director who simply has never grasped the idea. He may think he has, but all he has really done is pick up a few words. He has not even begun to explore the complicated problem of trying to translate the motivational approach into specific daily actions as a director. He may talk motivation, but he continues to think like a researcher rather than a leader of a group effort.

The second type of research director has grasped the meaning of the motivational approach. He has shifted his attention from research to the problems of motivating people. His problems arise because he soon gets into the subtle and complicated maze of needs which motivate people, especially people as complicated as research scientists. These enlightened directors develop one of two problems. Either they over-simplify, and their predictions about what will motivate people don't work out. Or they do not over simplify, but they get lost in the frustrating experience of trying to figure out just what does motivate people.

What often goes wrong in trying to use a motivational approach? One failure arises from trying to base motivational control on assumed needs which are too crude to be of much value. For example, people work for money. Therefore, if you want something from someone, set it up so that if he does what you want, it will lead to more money. This works up to a point; up to a point where a man has enough money for a reasonable supply of the things that money can buy. Then that need subsides to a position of relative weakness as a motivator, and some other need takes its place.

It did not take research directors long to see this. They moved on to talk about a need for status, or a need to belong, or a need for self-realization. This is a proper step. The problem now develops, however, of finding out just what really gives a man a feeling of status, or just what makes a man feel he belongs. Is it giving him a place on the planning committee? Or is it giving him a key to the executive toilet?

A director may decide on the right need for getting what he wants, but then he finds it hard to isolate and tap that need. Time and again he may initiate a program to get an action in return for its power to satisfy a personal need and nothing happens. Either the men don't have the need he thought they had, or he doesn't really offer what it takes to satisfy it. He only thinks he does.

Let us look at an example—the dual ladder in industrial research organizations. Research centers aren't getting the creative

programs they want. One reason for this is thought to be that most of the basic rewards in the industrial research environment are going to people in management positions. This leaves the research area as a weak motivational area both relatively and absolutely. Many potentially good research people turn to the greater rewards of management. Those who work on as researchers do so with poorly motivated energies.

The management ladder leads to more need satisfactions than does the research function. It leads to more money and more status. It was reasoned, therefore, that the way to motivate good research is to have it lead to as many need-satisfying rewards as does the management ladder.

So a research ladder was set up to parallel the management ladder. Equal steps with equal money, and presumably equal status. Does it work? Not very well. Why? Because calling the need-satisfying potentials of the two ladders equal does not make it so. And unless it is so, the researcher will remain anxious to get on the management ladder or will stay in research and produce mediocre effort out of mediocre motivation.

Why is the research ladder not yet effective? For one thing, there has been too much effort to make it lead to the *same* rewards as does the management ladder and too little effort to make it lead to *comparable* rewards. There has been too much effort to provide researchers with the things which motivate managers and not enough effort to find the particular things which will motivate researchers who presumably have at least one major area of basic needs which are different from those of managers.

Sometimes this difference is recognized, but another error is evident. You choose motivators of the right kind but of the wrong intensity. For example, you give the researcher the same freedom to follow his interests which the university gives the professor. That freedom motivates in the academic environment, but not necessarily in yours. What is overlooked is that man responds to the relative motivational possibilities of reward; not the absolute.

Freedom to follow your own interests is one thing when it means you are of the elite; the top group on campus. It is quite another thing when it goes with second class status or when it means being isolated. You can give the industrial researcher everything that motivates a research professor in his environment, and they will have little value in your setting if there are other rewards of greater relative value present in your environment.

The dual ladders must do two things to work. They must offer psychological rewards which are equal in summative power to satisfy needs, and the research ladder must provide powerful motivators which are relevant for the particular activity you want to motivate; namely, creative research.

One way to make the summative power of the two ladders equal is to have them lead to as many of the same rewards as possible. This you have tried to do, but not very successfully, in my opinion. How can you make the sum of rewards on the two ladders more nearly equal? Let's look at ways in which they are unequal. That should define the problem somewhat.

What are the relative chances that a man on either ladder will be promoted beyond the research center? I think experience will show the management ladder to have a higher probability. What is the comparable long term motivating force for the research man? What balances the fact that the manager gets the most phone calls from the status people in the home office? He more often gains the unconscious sense of importance from being called upon to deal with emergency problems. He gains more of the unconscious ego rewards from having power over other people and over his own actions. He gets more of the satisfactions which come from the respect of subordinates. Who has to refer to the other when it comes to deciding yes or no on money to be spent? Which one submits expense accounts and which one approves them? Which one decided who will go to professional meetings?

The manager has the most obvious control of the environment. He has the most urgent meetings. He has more knowledge of things to come and more to say about what they will be. Who

gives the final word on the new equipment or the new Ph.D.? Managers go to AMA or Harvard training programs. Besides going to conventions, where do researchers go?

In many of these things the ladders can't be the same because the rewards are peculiar to the management ladder. Very well, with what special motivators can you match them on the research ladder? What can you put at the top of it to balance the management ladder's possibility of promotion to a vice presidency with high salary and status? Perhaps, at a certain point on the ladder, you could introduce the idea of a sabbatical year every few years. Or at a certain point of research success you could send researchers away for specialized training. Perhaps at some point you could promote research men to complete freedom from accountability, possibly backed up with a staff of research assistants. Perhaps you could find ways to give them more control over their environment.

The successful manager ends up his days with status, still contributing from the judgment of experience. The old researcher seems more often to lose out to younger, more newly trained, more energetic men. He loses his intellectual edge and ends up his days on the fringe somewhere. In the university, he at least could become the venerable, respected old professor and teacher. He would have his professional reputation which economic competition makes it difficult for the industrial researcher to acquire.

The psychological point is this. If you direct a group, your real function is motivating and organizing the efforts of people, not directing research. If you accept this idea and adopt a motivational definition of your job, then your role is to see to it that what you want men to do for your program leads to their ego satisfactions. Then they will work for you. The success of a motivational management program depends upon how well you satisfy a multitude of small ego-needs rather than over simplified large ones.

Now let's turn to the concept of your job as a role. A research center is a social structure of positions which range from high to low on an authority-responsibility dimension. The direc-

tor's post is at the top of this social structure of defined relationships. In the structure, functions are distributed among a number of defined positions, such as manager, supervisor, chemist, and assistant. These positions, with the functions assigned to them exist independently of men. Men are inserted into the positions. People then tend to assume the man is the position; that the qualities of the position are invested in him. Some are, but the most important ones are not. They exist in the position.

Let's clarify the idea of the research director's job as a role by drawing an analogy. The job is analogous to a role in a play. A role is an integral part of the structure which is a play. A role exists in a definite and important relationship to other roles. It has meaning only in terms of the play and the other roles. When the play is given, a man performs the role. We then tend to think of the action as being a product of the man. In fact, much of it is the product of the role; it is merely conveyed by the player. The impact of the play on the viewer is conditioned by the personal qualities which the actor brings to the role, but the essential impact springs from the role. The man's actions must conform to the role or they can not be justified, and the play is a failure. If a given role calls for a negative and hostile influence whatever the quality of the actor, he must project the hostile influence. Your job is a role in the same way. It is a part; it poses a series of demands and expectations upon you which are defined by its role-relationship to the other roles of the research center play.

Just as on a stage, people in other roles expect your actions to be consistent with the functions of your role. Otherwise, they begin to lose their cues. I believe many of you don't really see your roles. You don't see fully what the structure requires of your position. You may not see what cues you must present in order to let your subordinates play the parts they should play, and which you want them to play. You don't live up to the expectations of your staff.

The higher your position in the structure, the more power of authority it has. When you take the role, you become the agent

of that power. Under the pressure of American middle class ethics, we tend to feel it is wrong to want power, to enjoy having it, or to act as if we have it. Many men unconsciously avoid any action which assumes power as their right. They seek actions which deny power differences from those around them.

What happens when such a man is in a research director role? The position has power requirements invested in it no matter what the man feels or does about it. In the eyes of subordinates the position is the source of rewards and punishments. It holds the key to promotion. It is the source of the criteria by which a man tells whether or not he is a success. It must be pleased; that power. It can fire him. It decides whether he is on the kind of research problem he wants to do. By definition, these and many other powers have been placed in the research directors position.

You enter the position. Your job is to apply the power as it is meant to apply in terms of structure requirements for keeping the group moving towards its goals. At once people below you in the structure ascribe all of the power to you. They must and they do react to you in terms of it. What happens when your subordinates consciously and unconsciously react to the power you have and you are unaware that you have it? Or you unconsciously avoid using it?

That power is a resource which a director should use deliberately and knowingly. He should be objective about it. He should know every way in which it is expressed in the group.

Few of you are guilty of abusing your power. You may be guilty of more subtle misuse, however. For example, you may fail to withhold the effect of your power when you should. Thus, you are the ultimate judge of what is right and wrong in your organization. Therefore, people seek to please you. In discussion with subordinates about their problems you may offer an opinion or suggestion. You may fail to see that this may carry the practical weight of a command when you are dealing with subordinates of certain personality types.

Every time a subordinate asks for advice, a director may give

it. With certain types he will be systematically removing the opportunity to learn to make decisions by this procedure. Or when a director becomes personally friendly with a subordinate and this is evident to the staff, he immediately invests some of his power in that person. Other subordinates begin to react positively or negatively to the friend in terms of the displaced power.

One director I knew prided himself in his ability to think technically and logically. When ideas were brought to him, he made a detailed critical examination of them. He did this out of habit of thoroughness and accuracy and a desire to be technically helpful. The subordinate, however, had the experience of seeing the man with power over his future find many flaws in his work. This director shut off the flow of half thought out brainstorms which often have a really creative kernel. How much better if he had recognized that his criticisms had the weight of authority and had found some way of getting the subordinate to find his own flaws.

I recall a research director who had a glimpse of his power as others saw it. He was walking toward his office at 4:45 to meet me. The center closed at 5:00. In the hall he met one of the cleaning women. As he passed her, he glanced at his watch. He was greatly startled to hear the woman protest "I'm not leaving, I'm just going to see so and so" whose office was near the door. He thought it very funny. But it illustrates perfectly that as a research director your image is a composite of you and your role. You may not see the power in your actions, but others do.

To your subordinates your image is the total of your qualities plus the qualities of your position. You are reasonably familiar with *your* qualities and you may use them well. You may not be so well aware of the position qualities you assume. You can lose your strength as a manager and leader because of this.

Your job is to motivate your staff. To do this your behavior must be consistent with staff expectations of your role, especially as they are reflected in staff needs. You must know those expectations. You must know the ways in which you may transmit your power inadvertently. You must know your role.

Status is another role attribute which is also often denied and unrecognized. It is a powerful and legitimate tool of a leader. Many men deny the status a position gives them and by doing so lose effectiveness and rob subordinates of a goal they strive for; the possibility of improving their own status. Status, like power is an important motivational tool.

I emphasize the importance of "role." It is so important an instrument for setting the needs your staff will seek to satisfy. If you give them the chance, play your part correctly, they will work hard to please you for their own satisfaction. And what pleases you is presumably good for the center program.

You want people to be more creative? How you play your role has a good deal to do with whether they will be. Few parents turn away a child who brings his first drawing to be praised. He is praised, and perhaps he goes away to draw again. I've seen directors, however, turn away a researcher with his tentative, creative idea. The pressure of practical projects claimed the director's attention. He didn't realize the researcher had sought to satisfy his need for approval by the boss. The director did not satisfy his need. But he saw the director's interest in practical problems. So, he turned to the practical.

You are not that important to your subordinates actions you say? They aren't children. No, but they are children grown; they have the same needs in subtler forms. And you have the authority they want to please in another form. Don't underestimate its motivational value.

I've been trying to illustrate a perspective. I chose to do this for two reasons. One is that the perspective or concept given is especially useful for people who work through other people. If expanded it has many practical implications.

The second reason is that my experience with physical scientists has taught me that as a group you are the sort of people in whom this perspective is slow to develop. Physical science seems to attract a particular personality type which stresses intellect rather than emotion, which is achievement-oriented, which tends

to be personally defended, to be outward oriented with a strong affinity for objective problems and objectivity. You tend to be closely controlled, to value reason and analytical thinking, and you avoid much basic self examination.

This personality type is a very civilized person, but he tends to take people at face value. Except in the most objective sense, he finds it hard to see himself as both a cause and an effect in his human relations. He becomes anxious when he really looks into himself and he has a feeling it is wrong to look into other people, or to plan the other person's reaction. But a natural leader does just that. It's what your jobs call for you to do. The psychological perspective helps. If it's not natural to you, you can still develop some of it with the same objective logic you used in becoming scientists.

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WHY NOT LET PUBLIC RELATIONS WORK FOR YOU?

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Twenty-five years ago it was often considered futile—if not downright dangerous—for a public relations man to approach his company's research department for a story. The research manager was usually just out of patience; and as for the research people in the laboratory, they had neither time nor interest in such goings-on. For publicity they couldn't care less.

There may still be some managers and research people of that kind, but theirs must surely be a disappearing breed. Both public relations and industrial research have grown greatly in stature these last 25 years, and both have begun to see ways of working together for the benefit of all concerned.

In one industrial laboratory, it was difficult not long ago for a public relations man to get so much as a pleasant good morning. Recently this laboratory held a full-dress community open-house, which was visited by upwards of 3,000 people from the city, including the faculties and senior classes of two high schools and a junior high.

The effect on the community of having this opportunity to see that hitherto secret establishment was tremendous. The local newspaper gave it front page space, with pictures. The mayor

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issued a statement praising the company and the director of research. The head of one of the high school science departments asked for some practical advice on improving his curriculum in the light of what he had observed about modern methods of research. And the research department received special praise from the president of the company for its contribution to the company's community relations.

The most important effect, however, from the viewpoint of the research director, was the reaction of his own people—the very ones who had for so long protested that they wanted none of the nuisance that goes with public relations activities—and none of the notoriety, either. The fact is that, when they saw their pictures in the local newspaper, they reacted just like other normal human beings. They passed the pictures around. They warmed with praise from their families. They were glad to receive the admiring comments of their neighbors. And they showed by renewed interest in their work that even a fellow who usually operates far beyond the average orbits of humanity finds it pleasant to be noticed.

Why are industrial laboratories and industrial research people rapidly becoming cooperative with—even interested in—Public Relations?

Well, for one thing, styles in interests—and pretended interests—change, like most other culturally determined phenomena. A generation ago the research man was a rare, almost unknown and little understood person in our industrial society. He still had to prove that his work was economically important—could lead to something. Because he was a strange animal in the corporate structure, he tended to *act* like a strange animal. Part of his protective coloration included a set of values apparently different from the rest of the organization. The company was interested in selling, manufacturing, making money—so the research man often adopted the attitude that manufacturing was dull, making money was rather crass, selling was something shady, or at best an activity only for philistines and lowbrows. As for the advertising and publicity usually associated with the selling process; they were beneath contempt.

A good deal of this kind of thinking has now gone by the board. The research man in industry no longer has to fight a lone battle, or wall himself up in a protective shell. He is now a mighty successful part of the organization in his own right, and, in some fields, indeed, he is coaxed, coddled, and courted as well as praised and rewarded. The columns of technical journals, and even those of the daily newspapers, are filled with advertisements from companies in electronics, engineering, and scientific fields seeking scientists and engineers. At least one advertising agency and several manpower agencies specialize in recruiting scientists and engineers. The research man is one of the most sought-after people in the whole industrial structure. If he still has an inferiority complex, it's simply a sign he's dated.

Further, the research department has begun to appreciate the source of the funds for more and better laboratories, better equipment, and bolder, more extensive research projects. These funds come from sales, and so this aspect of industrial life is indeed important. It is also interesting; demands special skills; makes full use of brains. In many companies, research scientists and engineers regularly team up with salesmen in approaches to big customers, ticklish customers, hard-to-please customers, and just plain prospective customers. Research and technology provide the new products, the better processes, the cost-saving methods, the new applications that power the sales program and keep a modern company competitive.

Along with all this, research directors and research people have had many actual experiences in recent years with public relations and advertising people—and behold—a lot of those experiences have been both pleasant and professionally rewarding. Public relations men and advertising men, too, have learned a good deal about research and technology. Many of them can at least speak the language of research, and understand some of the basic concepts. They also know a good deal about the scientists' professional attitudes and codes of behavior. As a result, research men now can feel "safe" with them, in a way that seemed impossible a few years ago.

As an art, profession or craft, industrial public relations has been rapidly developing during the last 30 years. It is now no longer simply a matter of press relations, publicity, and other attention-calling devices, though these are still very important branches of it. Industrial public relations today includes many other activities; has a philosophy of its own, with its own techniques, methods of research, codes of behavior, and ethics. It has its own national professional society and provides many other indications of increasing importance, growth, and maturity.

In its broader aspects, modern industrial public relations results from a conviction on the part of enlightened business and industrial managers that it pays to have what the Declaration of Independence calls "a decent respect to the opinions of mankind." This is a conviction to which most research men and research directors can also subscribe.

Generally speaking, industrial public relations is simply *the art of making more people want to do business with you.* By "doing business" one means, not merely buying your services or products, but also working for you, furnishing needed capital, supplying required materials and services, accepting you as a member of the community, and wishing you well.

In this context it is easy to see that a research organization, whether a department of a company or an independent research organization, has much to gain by applying the precepts and methods of public relations. The same is true for an individual research manager or a member of the staff. Through application of the principles of public relations, the manager or research man has much to gain personally, professionally, and for the organization of which he is a part.

How does one apply the modern principles of public relations? First of all, by having "a decent respect to the opinions of mankind," and second, by realizing that on the whole, the effective opinions of mankind are based on information and understanding. Hence, public relations in practice involves policy: some decisions about what you *want* the public to know and think

about you; and second, communications: the processes by which the specific public or publics of interest to you become informed.

In one way or another, everyone in our society is engaged in public relations activities, whether or not he knows it. Every decision or act affects what others think about us in some way; everything we say, whether to one person, a group, a crowd, or a nation, is a means of communicating our ideas, beliefs, emotions, or prejudices to others, and thus furthers the continuous, subtle process of molding the opinions of those about us.

The principal difference between what we all naturally do and organized public relations lies in the fact that the policies and techniques of the latter are consciously developed and applied, usually with a specific end in view. In the case of business or industrial public relations, the desired end usually is to win the interest, support, and patronage of the public. And one of the effective means by which this is done is the development of what in these days is called a "corporate image"—a mental picture or symbol of the company in the mind of the public which contains the elements of leadership, quality, progressiveness, prestige, or other facets that are considered most appropriate to the company, its situation, need, and product. Such an image or symbol to be accepted and "saleable" to the public, must, of course, be based on demonstrable truth.

Here is where the research laboratory can come usefully into the public relations program of an industrial company. Not only does research provide new knowledge, new products, additional uses for old products, and better methods, but it also can add enormously to the corporate image—to the prestige and leadership symbol of the corporation.

In these times, research understandably has a special attractiveness to the public—a special "glamor," if you can stand the word. But the public cannot be impressed by a company's research if it knows nothing about it. Therefore, many companies that have research organizations seek to make the fact known, particularly in ways which will be impressive to the appropriate pub-

lics, but at the same time will not give away trade secrets or adversely affect the professional standing of the research organization or the people in it.

This, of course, takes some doing, and is usually not very effective when undertaken by the amateur. Considerable insight, experience, and skill are required; consequently, companies usually employ professional staffs, or public relations counsel or agencies, to handle public relations. When a company has an internal public relations organization or outside public relations counsel, the research director will do well, both for his research organization and his company, to cooperate with it.

When the company does not have a professional public relations organization, it is often possible for the research department itself to employ a public relations man—either an independent counsel or one who is experienced in the field and can be added to the staff. His operations should embrace both *internal* relations—looking toward smoother teamwork and higher productivity within the organization—and *external* public relations: that is, better relations with the rest of the company, with the community in which the laboratory is located, with professional societies and organizations, with the technical and professional publications, and with the colleges, universities, and other sources of new staff members.

A skilled and experienced public relations man who understands technology will be able to find almost innumerable ways to build recognition and gain prestige for the research organization, at the same time enhancing the professional standing of its members rather than—as used to be feared—injuring it. The relatively simple procedures of obtaining wider publicity for papers presented at technical meetings or published in technical journals are a case in point. This type of publicity does not violate any professional ethic or cause any loss of priority, since it follows after the fact of publication or presentation at a technical meeting.

Many other effective, yet dignified means exist for attracting

suitable attention to the work of the laboratory, its personnel, its contributions to the company, and society as a whole. When a new laboratory is dedicated, technical people from other organizations together with science writers and general reporters may be invited to attend suitable ceremonies. An open house at the laboratory, when properly organized, can gain very useful local attention and interest, and appropriate publicity in newspapers and magazines may carry the story to large national groups of readers as well. Reports of outstanding research findings or accomplishments can be followed by demonstrations in the laboratory, or at one of the great centers of public communications such as New York or Washington, and thus gain recognition on a national scale for what otherwise might become known only to a relatively small group.

But why go to such trouble? What can be accomplished?

An old saying is, "better known means better paid." The research operation that would like to grow in order to reach new and greater heights of accomplishment continually needs to seek larger budgets. And larger budgets often follow public recognition for accomplishment in research. One well-known research organization, for example, was able to increase its annual budget from $200,000 to $15,000,000 annually in ten years with the aid of a public relations counsel. This was not accomplished entirely through public relations, of course. It resulted from excellent work by a fine staff organization which took full advantage of all opportunities. But the public relations attitudes developed in the organization helped in drawing rapid attention to major accomplishments, in bringing better people into the organization, and in attracting sponsors, customers, and cooperating organizations. This organization today is one of the largest independent research agencies in the country, and one of the most prosperous.

Another laboratory, which serves not one company but an entire industry, developed through its research a special type of product which should have been of wide interest throughout the industry, but for some reason was being accepted much too slowly.

It happened that a new laboratory wing was about to be opened by this group, and at the suggestion of a public relations counsel the occasion was built into a national event. There was an internationally-known speaker, an open house for employees and the community, and, most important of all, an effective demonstration of the special values of the new product. This demonstration was attended not only by invited guests but also by the presidents and research and engineering directors in the industry. Previous invitations to them to witness this new product in action had produced very little response. But in connection with the large national event, the demonstration took on new interest and importance. The result was adoption by more than half of the industry within a year.

As a means of coaxing outstanding new personnel into the organization, many a research laboratory advertises fine equipment, important projects, "California living," and the like. Many forget one of the most powerfully attractive magnets available: an opportunity for personal recognition.

In these days research men who want to get ahead realize that a satisfactory income or fine equipment alone may not bring happiness or a sufficient sense of accomplishment; this can often be achieved only through personal recognition from fellow-professionals, from other members of the company organization, and in many cases from friends and neighbors as well. Many a technical man has transferred his allegiance to the larger, well-known laboratory, simply because *it* was well known. How much greater an appeal could have been made by smaller laboratories had they pointed out the opportunities for personal recognition and advancement which they have to offer—and made certain through internal and external techniques of public relations that such personal recognition for individual staff members really was available.

The success of a research operation depends basically on the ability of its people, the skill and perceptiveness of its management, and the opportunities presented to it by the company or industry of which it is a part. But a decent respect to the opinions of mankind,

plus good communications with the technical, professional, business, community, and customer publics that can influence its success or smooth the way to greater accomplishment can be a mighty help, as many a research director has learned through experience.

Good public relations is an asset—and fortunately it is available to almost any research organization that wants it.

RESEARCH MANAGEMENT VOLUME IV, NUMBER 4 (1961)

FINANCING OF VENTURE PROJECTS

DON C. WHEATON, JR.*

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New York, New York

Research produces new products or new processes for old products. In the large corporation there is no problem of financing in upgrading the results of research into actual production and selling facilities. But what of the researcher in a small company or the individual who has come up with something that he believes can be successfully exploited? Where can the technical man who wants to start a new project obtain the necessary financing? And what does he need to convince the source of money that his project is deserving? We have talked with many technical men who have these problems. Curiously enough, we have found that a person who would never start a research project without gathering all the available information into an orderly presentation, and without plans for the work to be done, yet may ask for financing without a semblance of a planned presentation of the facts needed by the financier to reach a decision. Whereas he will spend months planning and studying a research project, he often asks the financier to make up his mind in a few days. What information is needed and how should it be presented?

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The money man must be convinced of three basic facts: There are raw materials available, the process will work, and the output can be sold at a profit. Following these must be a concise plan of the money needed to initiate the project and to carry it through to completion. Then, proper time must be allowed for full consideration and checking of the information.

Each of these points merits discussion. The best raw material situation is covered by a long term supply contract at a fixed price with a reliable company. The closer to this ideal the entrepreneur can come, the easier it is to convince the money supplier the project is worthy of consideration. However, it is readily agreed that this perfect raw material situation cannot often be achieved.

In ordinary cases, a material that is in good supply on the open market with a history of limited price fluctuations is satisfactory. Where there are but a few sources of a material, an indication in the form of letters of intent from two suppliers might serve the purpose. The unsatisfactory case is where there is but one or two sources to whom the particular product is of secondary importance. Here the chances exist of wide price fluctuations, or shortages, or even complete elimination of the material. Another risky situation could be where a new manufacturer agrees to make the raw material. This can be turned to advantage by adequate proof that he can make the product at a satisfactory price.

The next point to consider is the process. If it is at all new and unproved, the chances are a report on the process by an independent reliable consultant will be requested. This usually brings loud cries of anguish from the entrepreneur. His process is secret and very valuable. Others will steal it. He will tell no one about it. Let me make clear that no reasonable source of money is going to buy a pig in a poke. The solution, of course, is a proper secrecy agreement with the consultant. It should be pointed out that consultants in the chemical field, as well as banks, deal with confidential information all the time. Any violations of such confidences would be ruinous to their business.

The third key to financing a new project is the marketing. There must be assurance the output can be sold at a profit sufficient to pay off any loan and to earn a substantial gain for the investor. Once again the ideal is a take or pay contract for the output from a reliable concern at a price to ensure a successful operation, although this perfect situation is not often attainable. Another variation is a contract for requirements from a reliable concern with a history of using amounts comparable to the output of the new plant. Sometimes suitable is a contract for a good selling organization to use their "best efforts" to sell the output. Unless the entrepreneur can show that his product has a substantial advantage, such as in price or quality, over competitive items, the entrepreneur's plans to sell his own output will not be convincing. Certainly his own efforts will not be accepted without evidence of the organization of a good sales effort and without an independent market survey.

The next step to convince the potential backer of what we might call in fancy terms, the economic feasibility. Can the project make money on the basis of the costs involved? Many technical men fall down at this point because they have not made a detailed examination of all the economic factors involved. Particularly is this true in regard to plant investment. The financier has a general knowledge of the purchase of raw materials and of marketing but he is generally lost on the evaluation of a chemical plant. There are sources of money such as ourselves and a few New York underwriters who have people with some knowledge of chemical production and will at least understand the problems. The ideal situation is a fixed cost, turn-key contract with a reliable construction firm. At any rate, there must be assurance that the plant can be constructed within a definite amount of money.

Most important of the data to be presented is a detailed cash flow for the first several years. This will start with the cash cost of the plant; cash needed to cover expenses before money is generated by the manufacture and sales of a product. It will con-

tinue with the cash to be earned and will conclude with a cash income that will pay off any money borrowed for the undertaking. Next must be a detailed projection of expected profits. Detailed projected balance sheets will also be helpful. Note the repetition of "detailed." The financing agent doesn't particularly want to wade through mountains of detail, but there must be sufficient material for him to conclude that the results shown have been reached by careful study and consideration of the many facts and facets of the project. The matter of management also comes under the subject of economic feasibility. Perhaps the project promoter has the capability to run the new enterprise. If not, there must be a capable individual available to take the job. There must be assurance that second line jobs, such as plant manager and controller, can be filled capably.

Let's assume the researcher now has his undertaking ready for presentation. What should he ask for? How much money can he expect to get? How much can be borrowed? I think it is basic to assume that the entrepreneur and any investors associated with him want to borrow as much as possible. The percentage of loans against equity is a function of the amount of risk. The perfect project with good contracts for raw materials and for the sale of the product with a proven process of manufacture and a reliable contractor can borrow well over 50% of the cost. An operation with none of those factors present will not be able to borrow at all.

The same principle follows for the terms of obtaining equity money. The ideal project can obtain this type of money by giving up but a small percentage of the ownership while the unproven will necessitate giving up over 50%. While the money source, after studying the project, will have some definite ideas as to the percentages and terms, I think, psychologically, it is best for the entrepreneur to ask for something definite rather than enter discussions with nothing to negotiate from his side. There is one other psychological factor: the entrepreneur must be willing to risk a good part of his own assets. No lender or investor will

advance his money unless the promoter will show such tangible evidence of his own faith in the new operation.

The researcher turned promoter is now armed with enthusiasm and with a well-ordered presentation of the facts. Whom should he approach? The cheapest and least complicated form of borrowing is a straight bank loan. If there are at least some of the riskless elements to the project, and the cash flow shows a payout of five years or less, a bank can be interested. If the project, although sound, requires a loan of over five years, an insurance company could be the source. Both of these will require a loan agreement which will spell out the requirements of the loan. While the bank will charge only an interest rate plus a bank account, it is possible the insurance company will ask for a minor part of the equity as a "sweetener."

Small business investment corporations are a source of long term loans, and they are willing to assume a little more risk but in return they receive a percentage of the equity, usually in the area of 10 to 25%, in addition to the interest rate.

If the project has real merit but not much of the riskless element, a private placement is a good possibility. Generally speaking, this would take the form of long term borrowed money, but there would be equity attached, probably in the area of 20% to over 50%. A few bank affiliates and underwriters also do this type of work.

The public can be the source of funds for a new project. However, several problems should be considered before succumbing to the lure of selling stock to the public. First, it is expensive. Underwriters fees, lawyers fees in connection with SEC requirements, and other compensation to the underwriters in the form of stock options, amount to a considerable figure. In addition, it means a number of diverse people are stockholders to whom the entrepreneur is answerable. If the project has a record of several successful years, then a public offering can be done more reasonably and it is a good way for the owner to realize on the results of his efforts.

Perhaps this brief, simplified discussion of the requirements for financing gives the impression that with the right approach to the right place, money will be forthcoming. This is wrong. Money for new projects, better known as venture money, is the most difficult kind of money to obtain. Still, with the proper ingredients well presented, the chances of finding it are good. I do hope that these notes will give to the technical researcher an insight into the problems of finding financial backing for his project.

COMMENTARY ON NEW BOOK

Ideas, Inertia and Achievement. F. B. Turck. The American Society of Mechanical Engineers, New York, N. Y. 1960. $5.00.

"Ideas, Inertia and Achievement" is the result of an unusual study conducted by the American Society of Mechanical Engineers. The study was based on the premise that there is a threatening and long standing time lag in translating original scientific research into practical application in the Nation's industrial and military machine. The study also assumes that much of the money expended on original scientific research is being wasted because of the slowness with which these results are translated into practical benefits. It is also assumed that the controlled economy countries may be doing better than we are in shortening the time lag. Questionnaires were sent to over 100 individuals, corporations, and institutes to collect ideas on the nature and causes of this time lag, and what could be done about it. The book consists of an organized selection of comments from this group. Comments from the various participating organizations are identified by author and are collected under such chapter headings as Communications, Management, the Soviet System, Corporate Planning, and the Institute Approach.

The assumptions on which this study is based are obviously open to question and, as might be expected, many of the respondents take issue with these assumptions. There is considerable difference of opinion as to the seriousness of the time lag and as to whether the situation has become worse or has improved in recent years. There is considerable opinion expressed that the situation differs greatly between industries and between competitive industries on the one hand and military activities on the other. However, there is general agreement that shortening the time lag is a desirable and necessary objective.

The book probably suffers from a lack of a clear-cut distinction between time lag problems in competitive industries and those of military significance. Some of the general comments dealing with necessary improvements in our educational system and handling of the explosive increase in scientific information apply to both areas. Certainly, in competitive industry a big factor affecting the time lag is simply the necessity for making sure that a particular project will be profitable. In the military area, in peace time, the biggest

problem seems to be dealing with bureaucratic red tape and getting decisions in some governmental organizations.

The chapter on the Soviet System, author not indicated, gives a rather rosy picture of the Soviet system. Whether such a system is actually doing better than ours depends on what criteria are used. The Soviet system, by concentrating in some segments of the military area, may well be ahead of us, but certainly if standard of living is taken as a criterion the Soviet system is not doing nearly so well. We suspect that Soviet methods for handling the time lag look better on paper than they actually are.

Much of the material in this book is of necessity rather general although some of the authors discuss fairly specifically what their particular organizations are doing to combat the time lag. Some of the excerpts are pretty dull reading, while other sections are both profound and inspirational. Since the book is a collection of ideas of a large group of thoughtful people expressing themselves on the same subject, there is bound to be some duplication of ideas. More importantly, just about all conceivable aspects of the time lag problem are examined from a number of points of view. Hence, this book should be worthwhile reading for all people interested in the translation of research results into practical application. This reviewer must observe, however, that the book contains neither a table of contents nor an index, which detracts from its value as a source of reference.

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(signed) ERIC S. PROSKAUER
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Sworn to and subscribed before me this 13th day of September, 1961.
(signed) Adelaide Rena Prenner

[Seal]

Notary Public
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(My commission expires March 30, 1963)

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